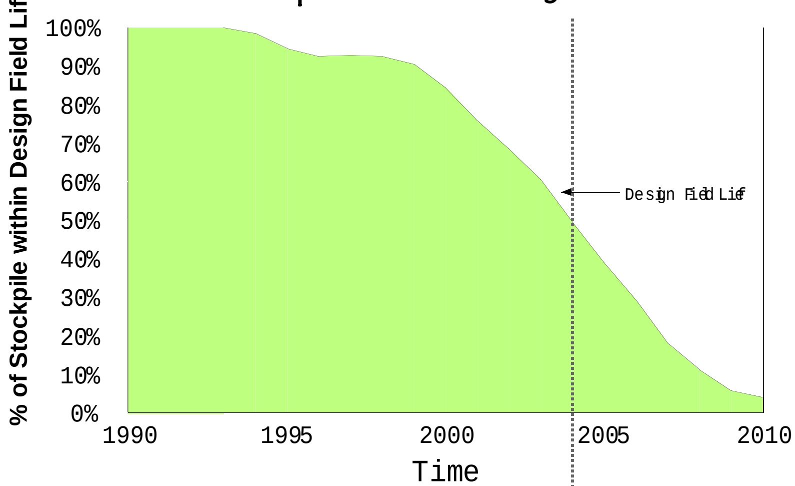
The Accelerated Strategic Computing Initiative (ASCI)

A Program Update and Progress Report
February 1998

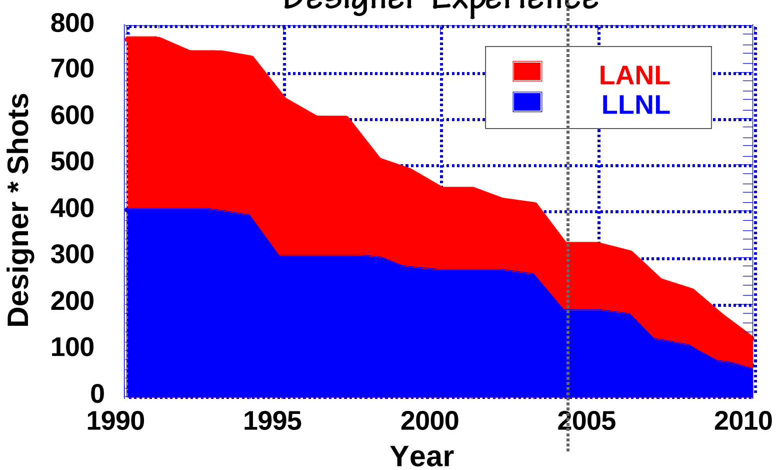
Program plan has been sized to meet technical requirements when needed

Trends

Nuclear Weapons within Design Field Life

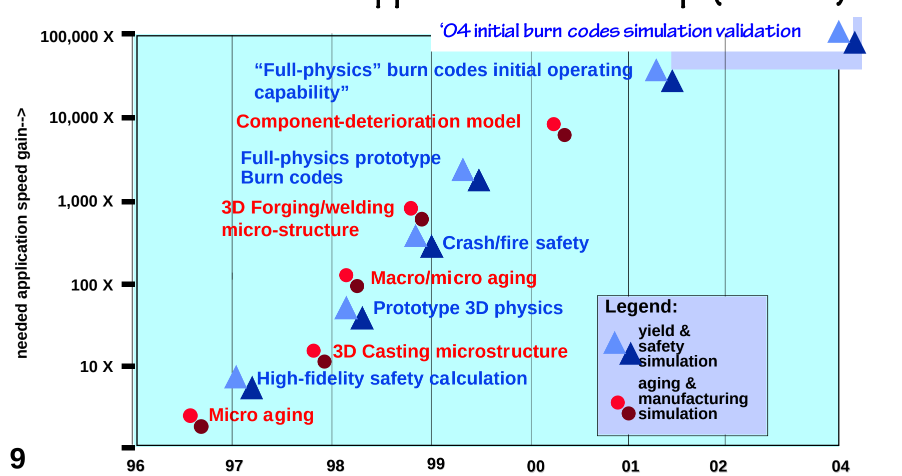


Designer Experience



- The absolutely essential requirement of having intimate involvement by the test-savvy designers in the validation of the simulation codes, including initial, exploratory validation with 100 TeraOp system in the 2004-time frame, establishes the technical justification and requirement for the current spending level and pace in ASCI.

Consolidated Applications Roadmap ("Curve")



ASCI responding to the Challenges

Challenge:
Stockpile safety, security, and reliability with no underground nuclear testing under Comprehensive Test Ban Treaty (CTBT) → Stockpile Stewardship Plan (SSP)

ASCI Response:
Weapon Performance & Safety Code Simulations

Challenge:
Indefinite Life Extention → DP Stockpile Life Extention Program (SLEP)

ASCI Response:
Codes to simulate aging weapon's materials and parts

Challenge:
Remanufacturing weapons parts with reduced time, cost and defects → Advanced Design and Production Technologies (ADaPT)

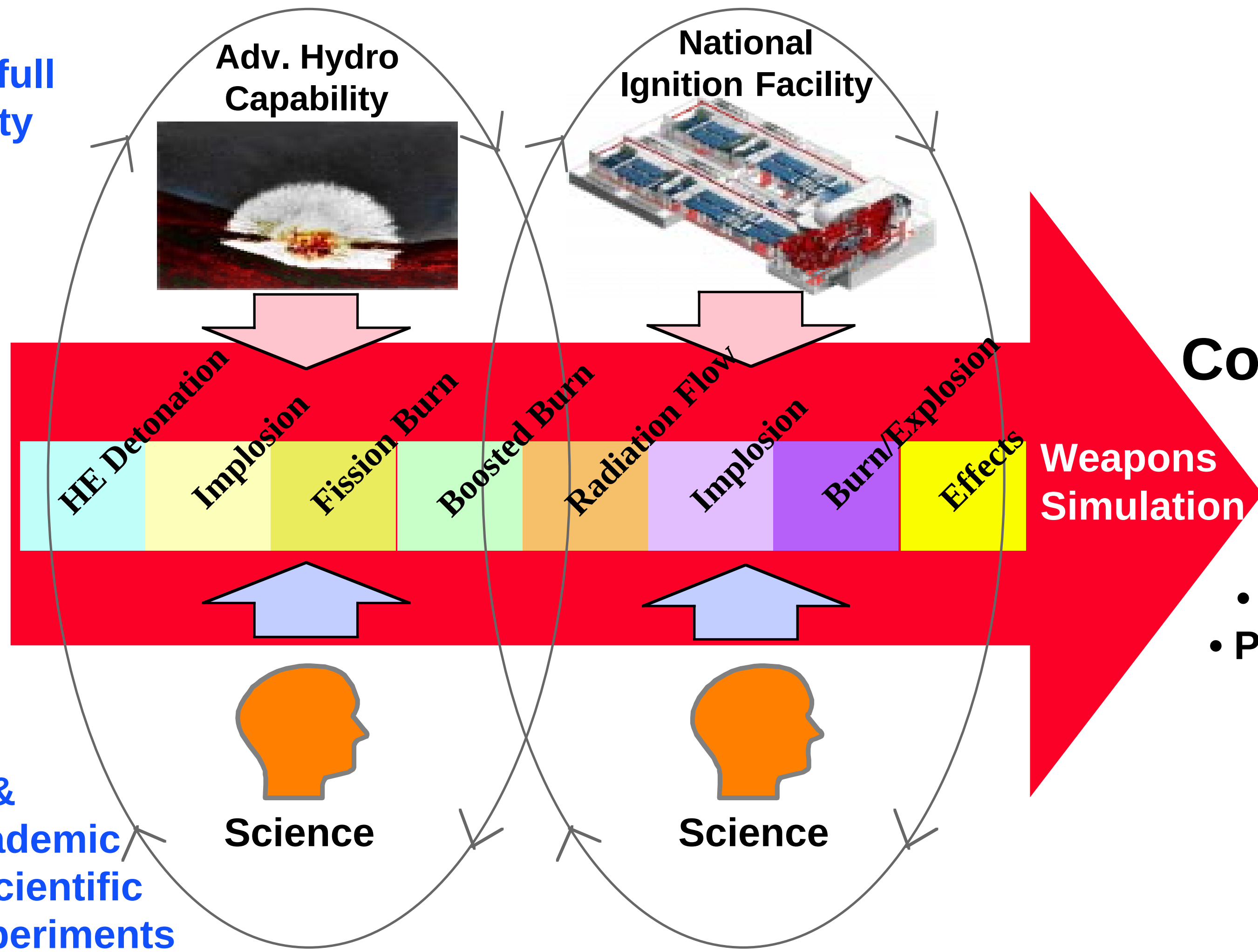
ASCI Response:
Virtual Prototyping Simulations

We are focused on the problem...performance, safety, reliability, and maintenance of the stockpile without nuclear testing..."forever"

① Full scale or full energy-density studies & experiments

② Computation & Modeling

③ World-class & forefront, academic & lab scale scientific studies & experiments



Confidence

in

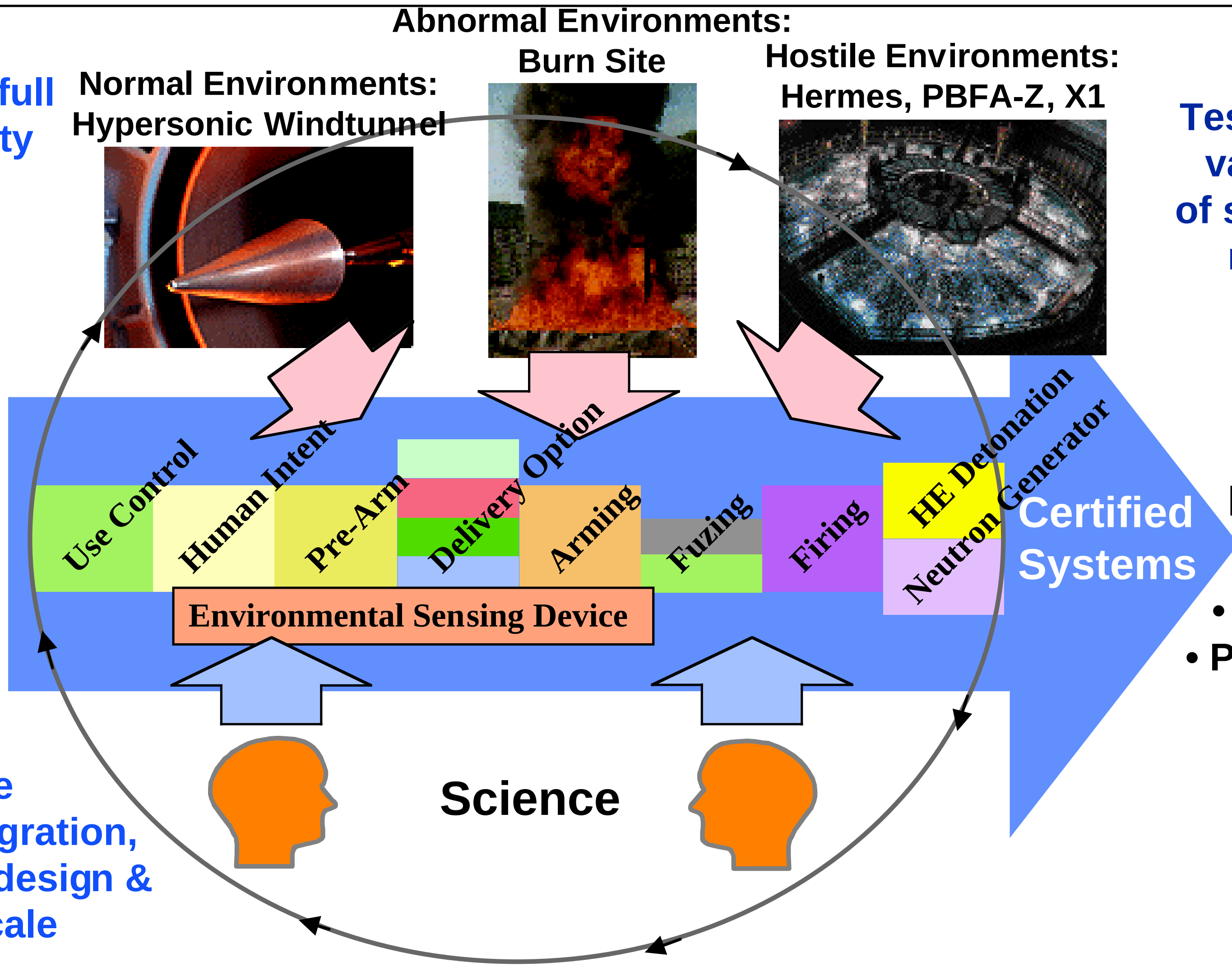
- Safety
- Reliability
- Performance

Simulation-Based Certification of Weapon Systems (or Aging Components) for Normal, Abnormal and Hostile Environments

① Full scale or full energy-density test & evaluation

② Simulation & Modeling

③ Leading Edge systems integration, engineering design & laboratory scale experiments



Test data for validation of simulation models

Input to Physics Package
- Safety
- Reliability
- Performance

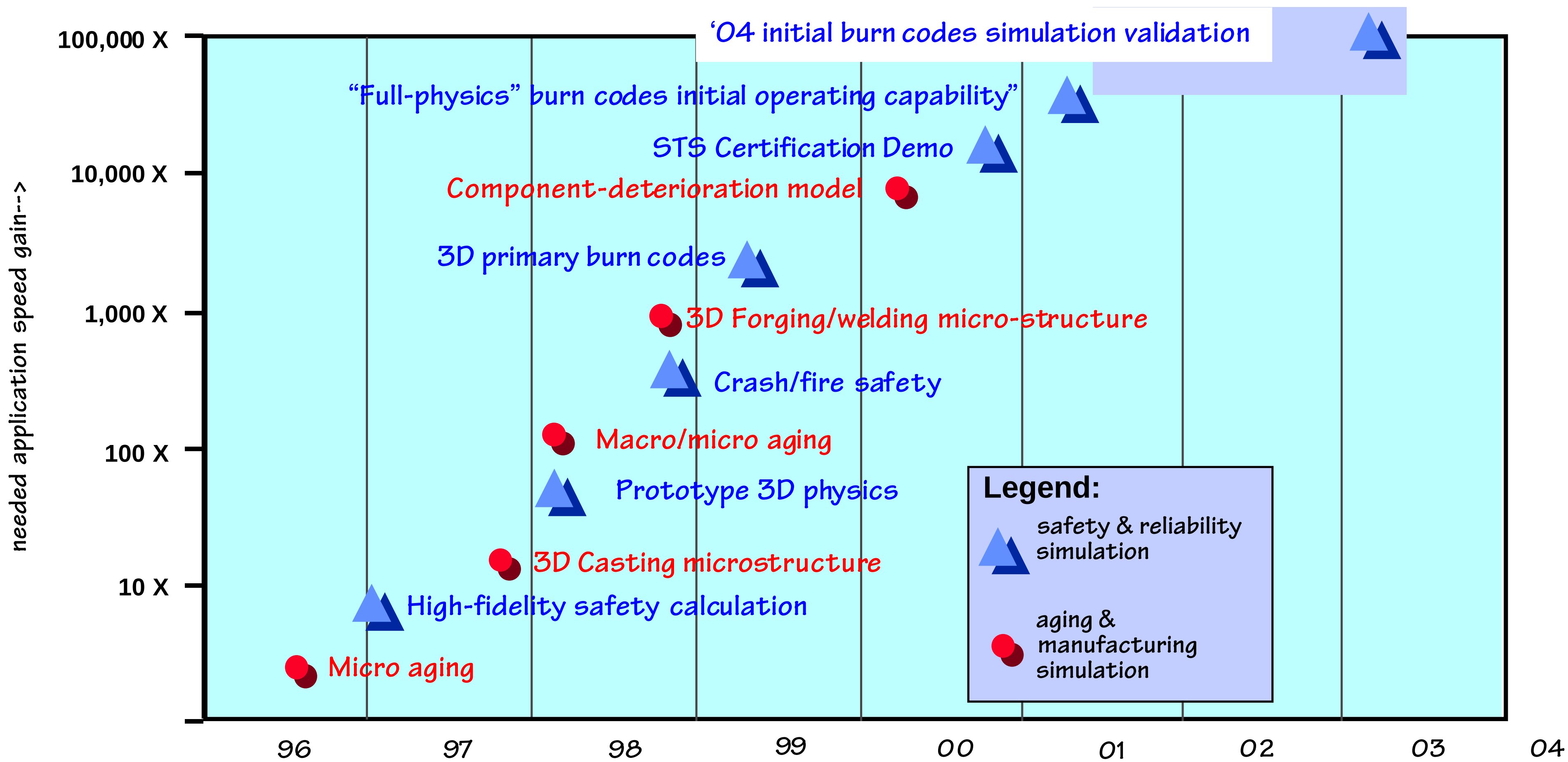
The Mechanics of Crash & Burn for Non-Nuclear Safety

- Structural Impact
- Fuel Dispersal
- Fire Dynamics
- Thermal Insult
- Chemical Decomposition
- Pressurization
- Fracture
- Gas Expansion
- Electrical Insult

RATZEL/5-96/03

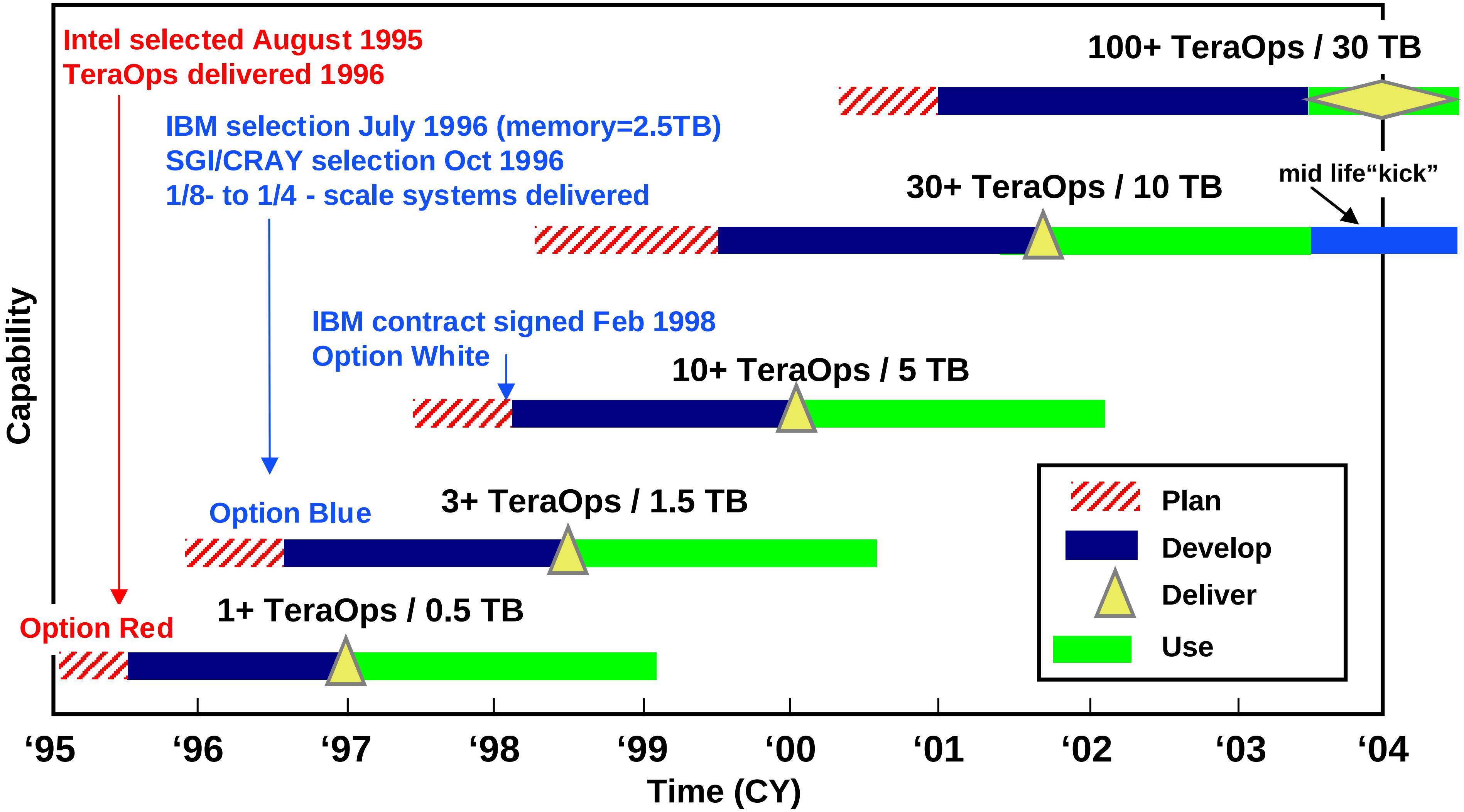
Consolidated Applications Roadmap ("Curve")

...3D-"more-complete-physics"-high fidelity simulations, has key milestones tied to stockpile requirements or expected aging and manufacturing requirements--i.e.,Green Book or SDR

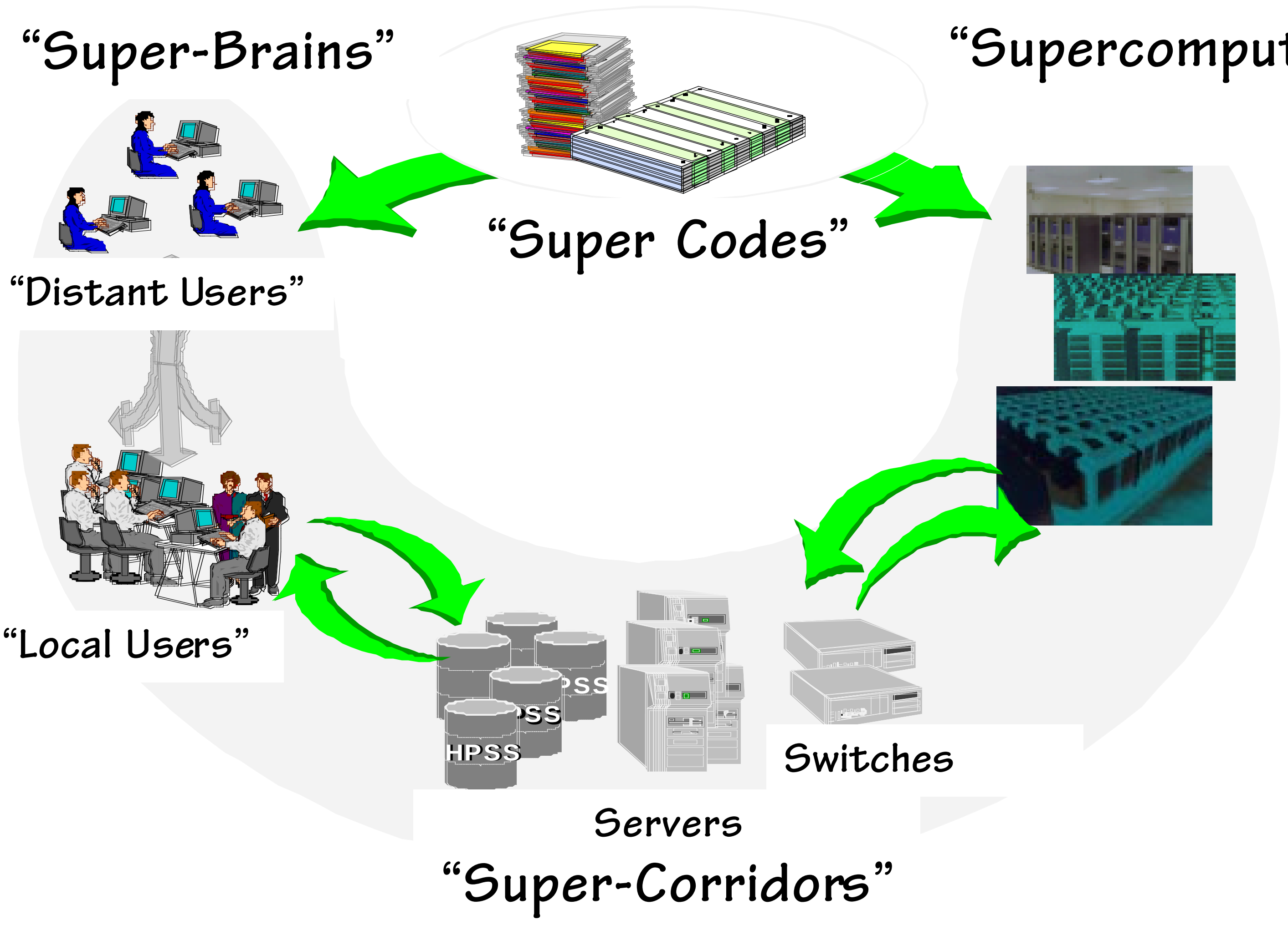


Platforms Computing Systems Roadmap

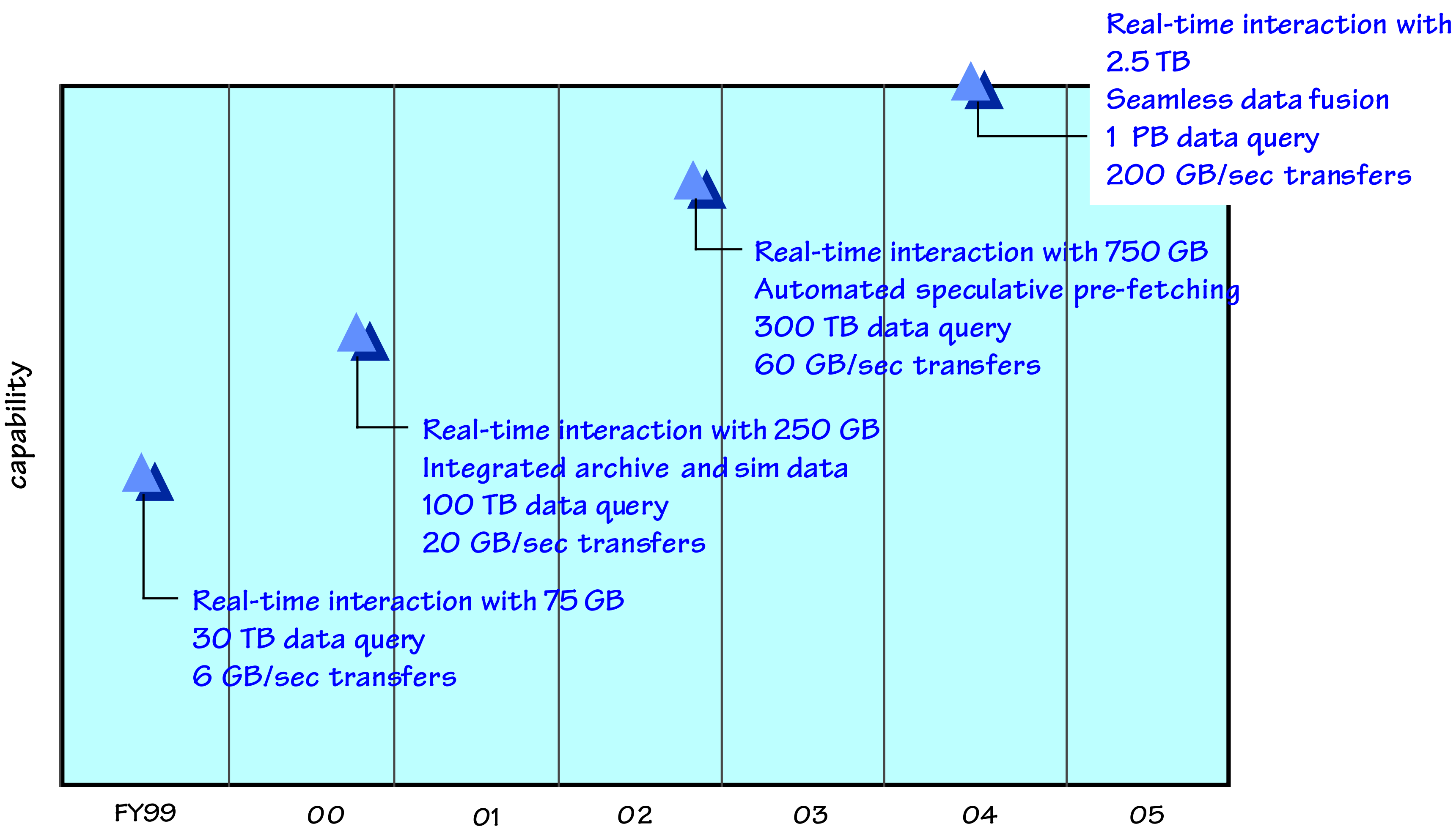
--working with the U.S. computer industry to reach unprecedented computer performance--



ASCI is more than just supercomputers



SuperCorridors Performance Roadmap ("Curve")



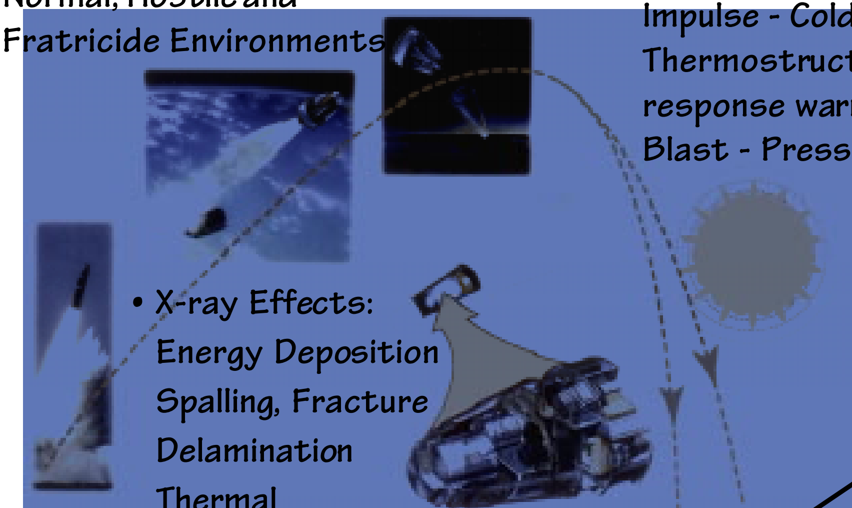
Performance Simulation- Successes

STS Certification Process

Normal, Hostile and
Fratricide Environments

Reentry
Impulse - Cold x-rays
Thermostructural
response warm/hot x-rays
Blast - Pressure ball

- ASCI is developing a comprehensive, validated simulation based approach to use for hostile environment certification.



- X-ray Effects:
  Energy Deposition
  Spalling, Fracture
  Delamination
  Thermal
  Expansion

- Certification Simulation for Mechanical Response of W76 Replacement NG ($3x10^5$ node hours on ASCI Red) performed in FY98

Primary Code - LLNL

FPO
Classified

Primary Code - LANL

Shavano Project

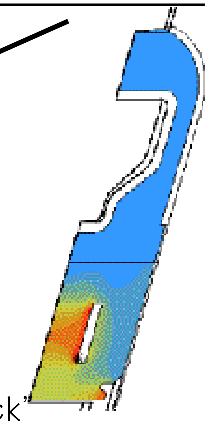
Virtual Prototyping - Successes

FPO
Classified

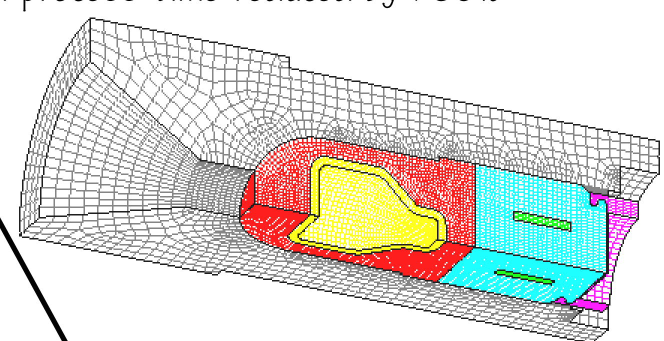
Pit Casting

- Simulations identify special preheat profiles to allow voidless casting of thin walled sections
- Collaboration between Teluride code team and plutonium foundry process team
- Optimize mold and casting design

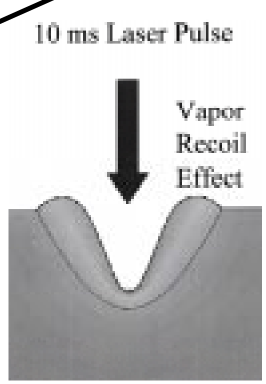
Encapsulation



Modeling
- Cure-time was process “bottleneck”
- Simulations identified improved cure schedule
- Coupled 3D fluid/chemical/mechanical physics
- Overall process time reduced by >50%



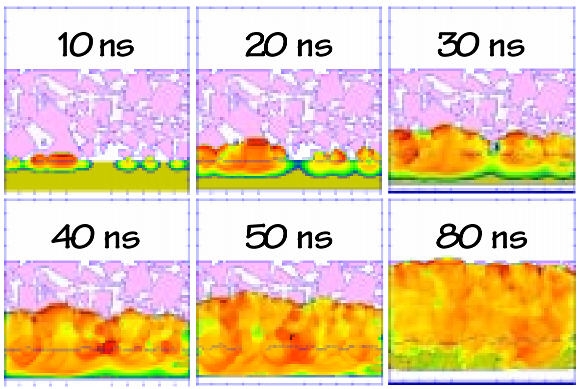
Laser Welding



- Recoil pressure from vaporization is key process phenomenon
- Vaporization/Recoil effect quickly implemented in MP-GOMA code (coupled physics, thermal/mechanical with phase change, capillary hydrodynamics)
- Can now (FY98/99) design process for dissimilar metal weld on MC4217 detonator, weld on RTG and (debris reduction) in NG tri-clad welds

Virtual Aging- Successes

High Explosive

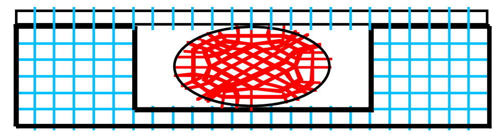


- Modeling leading experimental discovery

- Successfully predicted behavior of aging HE (W76 Fireset)
- Fine scale to physics coupled to engineering analysis currently available on ASCI Red, allows discovery of fundamentals of shock initiation

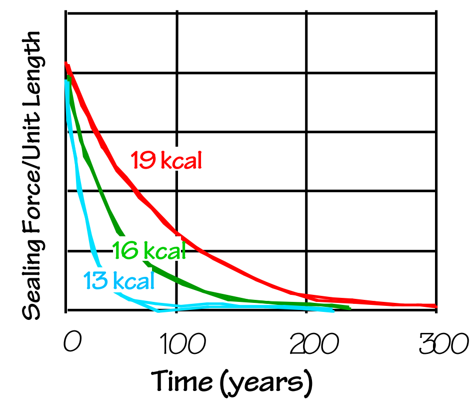
W76/W87 Butyl O-rings

- Developing the capability to predict loss of material integrity



Finite Element Analysis with JAS3D code

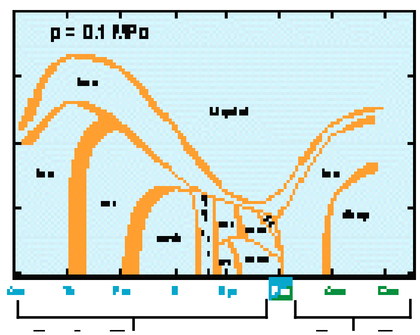
- Microscopic chemistry drives lifetime uncertainties



Loss of O-ring sealing force as a function of time and activation energy at 27^{0} C

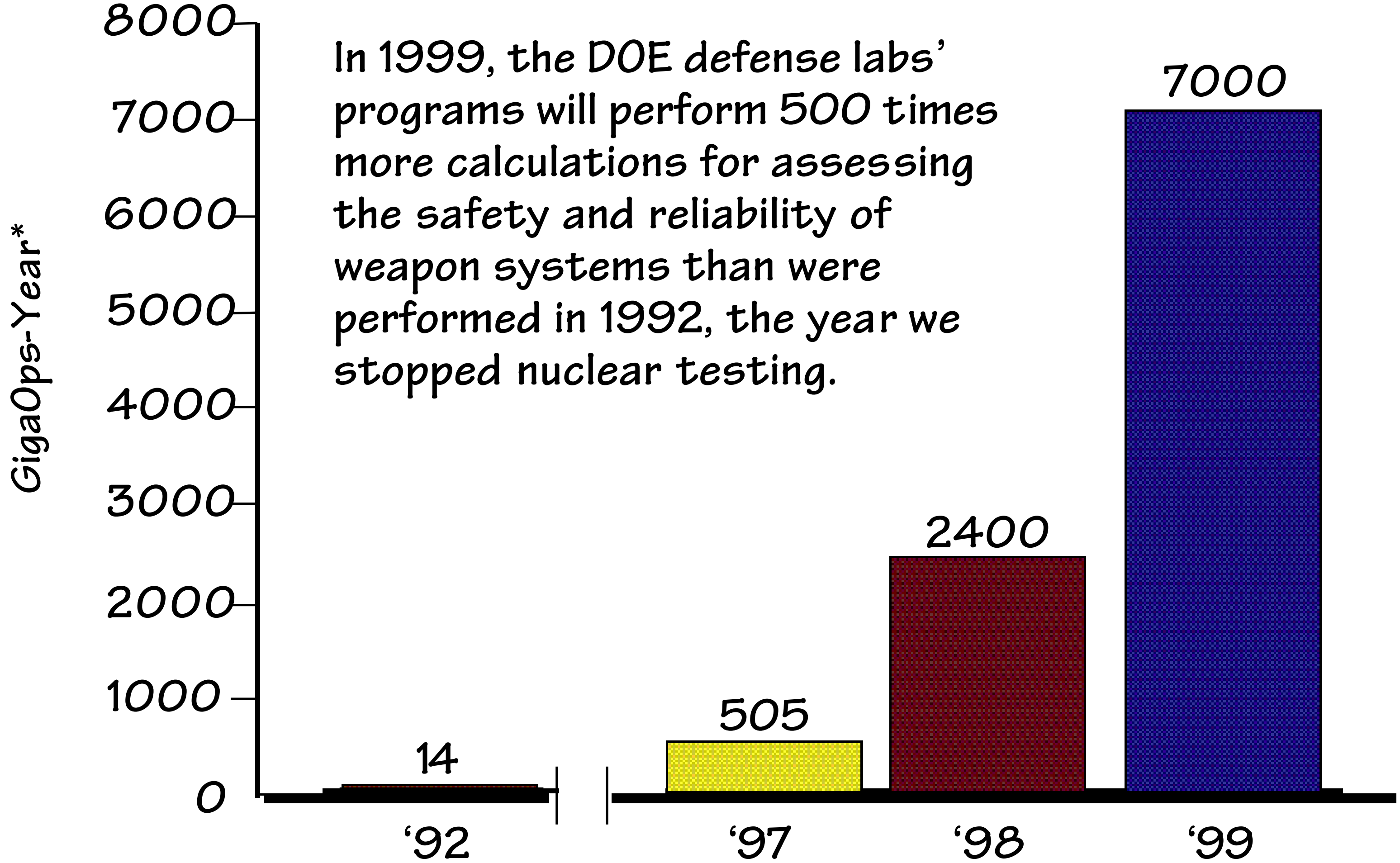
Plutonium

- Developed Pu aging simulation tools for atomic forces and structural phase transformations
- Did calculations of high pressure elastic constants for body centered cubic (bcc) Pu from first principles, resolving anomalies in historic test data



Improved Pu EOS

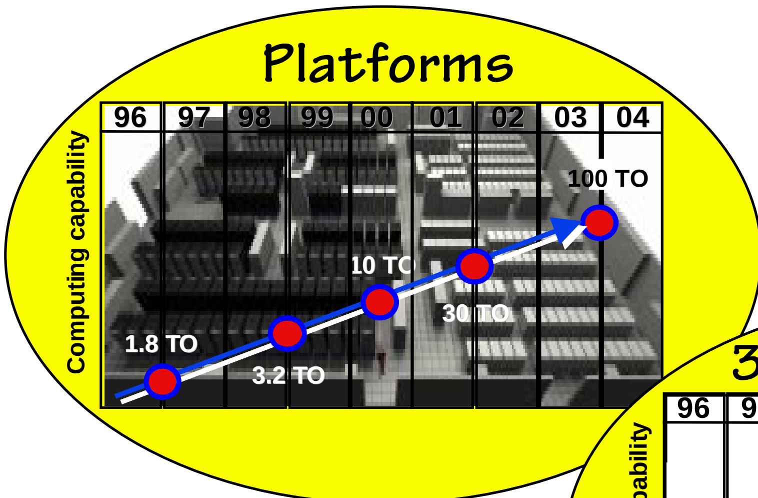
Yearly DOE defense labs' calculation volume for weapon programs

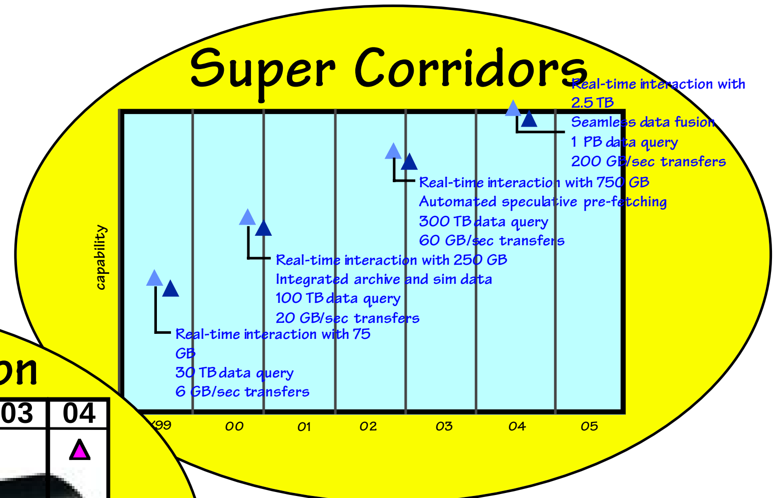


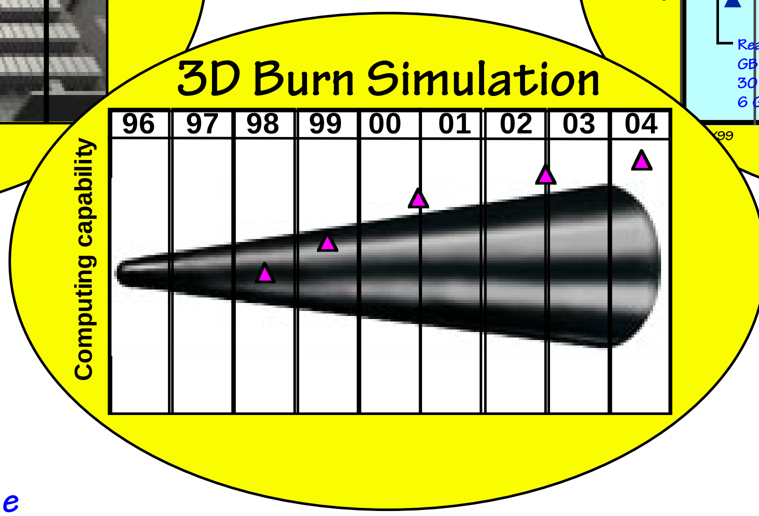
*GigaOps-Year= equivalent of one billion calculations per second computer running non stop for a full year

FY99 is a big year... first systems level demonstration

- First demonstration of an ASCI high fidelity 3D Primary Burn Code
- Application: W-88 Pit Rebuild Performance Assessment







3D Burn Code run on an ASCI computer...

- 1.5 billion cells
- 1.8 TeraByte memory
- 2-3 TeraByte secondary storage
- 3 TeraOps machine speed

- Full 3D, engineering configuration
- Assess impact of aging imperfections

...with results visualized by designers on advanced supercorridors

- 75 GigaByte real-time viz
- 6 GigaByte/sec network speed
- 30TeraByte data buffer

Full burn Simulation

FPO
Classified

Fiscal Year 1999 ASCI Budget

Applications	$152.0 M
Platforms	$70.0 M
Problem Solving Environment	$ 45.8 M
Alliances	$ 13.5 M
One Program 3 Labs	$ 6.0 M
V & V	$13.4 M
DisCom^2	$28.4 M
Total FY99	**$329.1 M**

Fiscal Year 1999
Stockpile Computing Budget

Stockpile Computing	$155.9 M
Numerical Environment for Weapon Simulations	$31.0 M
Facilities	$ 1.8 M
Total FY99	$188.7 M

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Backup VuGraphs

Strategic Computing and Simulation for Stockpile Stewardship and Management

...meeting CTBT and "Green Book" Requirements

Strategic Computing and Simulation Program

Accelerated Strategic Computing Initiative (ASCI)

- ASCI provides the leading edge, high-end simulation capabilities needed to meet weapons assessment and certification requirements without nuclear testing.

Distance Computing and Distributed Computing for Weapon Simulation (DisCom^2)

- Develop, integrate, and provide technologies needed for DP labs and plants to efficiently apply high-end and distributed computing resources (from desktops to TeraOps) across thousands of miles.

Validation and Verification (V^2)

- Provide the tools, methodologies and data to ensure that the high end simulation capabilities reflect and predict the real world.

Stockpile Computing (SC)

- Conduct computing operations, models development and code maintenance to support execution of the SSMP

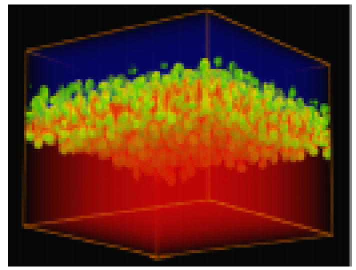
Numeric Environment for Weapon Simulation (NEWS)

- A local computational environment for large numbers of designers to use high end simulation capabilities to simultaneously address large numbers of stockpile issues

ASCI

Computers

Develop massively parallel, high performance computers to achieve the ASCI 100 TeraOps computing goal by 2004



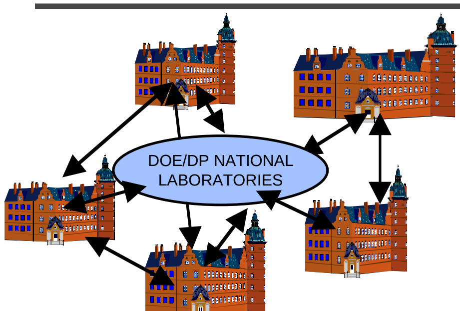
Applications Codes

Modify and develop codes to achieve the speedup's and improvements necessary to perform full physics simulation

V & V

Provide the tools methodologies and data to ensure that high-end simulation capabilities reflect reality

- Establish confidence in the predictive capabilities of ASCI tools



Alliances

Partner with universities, to solve computing and simulation challenges for 100 TeraOps platforms

Problem Solving Environments

Make the full-physics codes user friendly to weapons analysts including set-up of large scale problems, transferring and storing tera-byte size files, and 3D visualization on the desktop of these tera-byte size files

DisCom^2

- Implements secure Tera-scale computing across 1000s of miles
- Integrate information and simulation
- Install distributed security and resource management
- Demonstrate high capacity distributed computational plant

ASCI Systems

ASCI "White" IBM computer, Lawrence Livermore National Laboratory
10 Teraops, Contract FY98 Delivery FY-00

ASCI "Blue Pacific" Computer
Lawrence Livermore National Laboratory
3 TeraOps

ASCI INTEL "RED" TeraOp Computer
Sandia National Laboratory

ASCI "Blue Mountain" SGI/Cray Computer
Los Alamos National Laboratory
3 TeraOps

New Efforts in FY99

DisCom^2

Distant and Distributed Computing

- Secure Tera-scale computing across 1000s of miles
- Integrate information and simulation
- Distributed security and resource management
- High capacity computational plant

V & V

Verification and Validation

Verification

_ Unit Testing
_ Regression Testing
_ Code Coverage
_ Bug Tracking
_ Code-to-Code Comparisons
_ Configuration Control

Quantification of Uncertainty

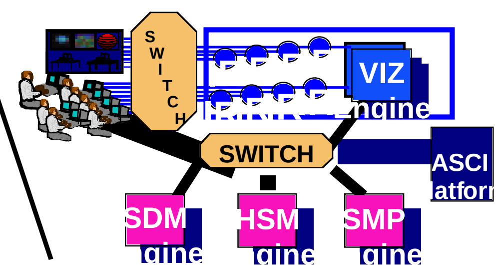
- Certification of Code
- Certification of Analyst

Validation

_ Existing Databases
_ Material Model Validation
_ Other Programs

Numeric Environment for Weapons Simulation NEWS

- Open ASCI TeraFlops capabilities to multiple users and multiple weapons issues simultaneously
- Provide collaborative environment and facilitates peer review
- Provide 3D visualization to desktop and real time immersive visualization environments



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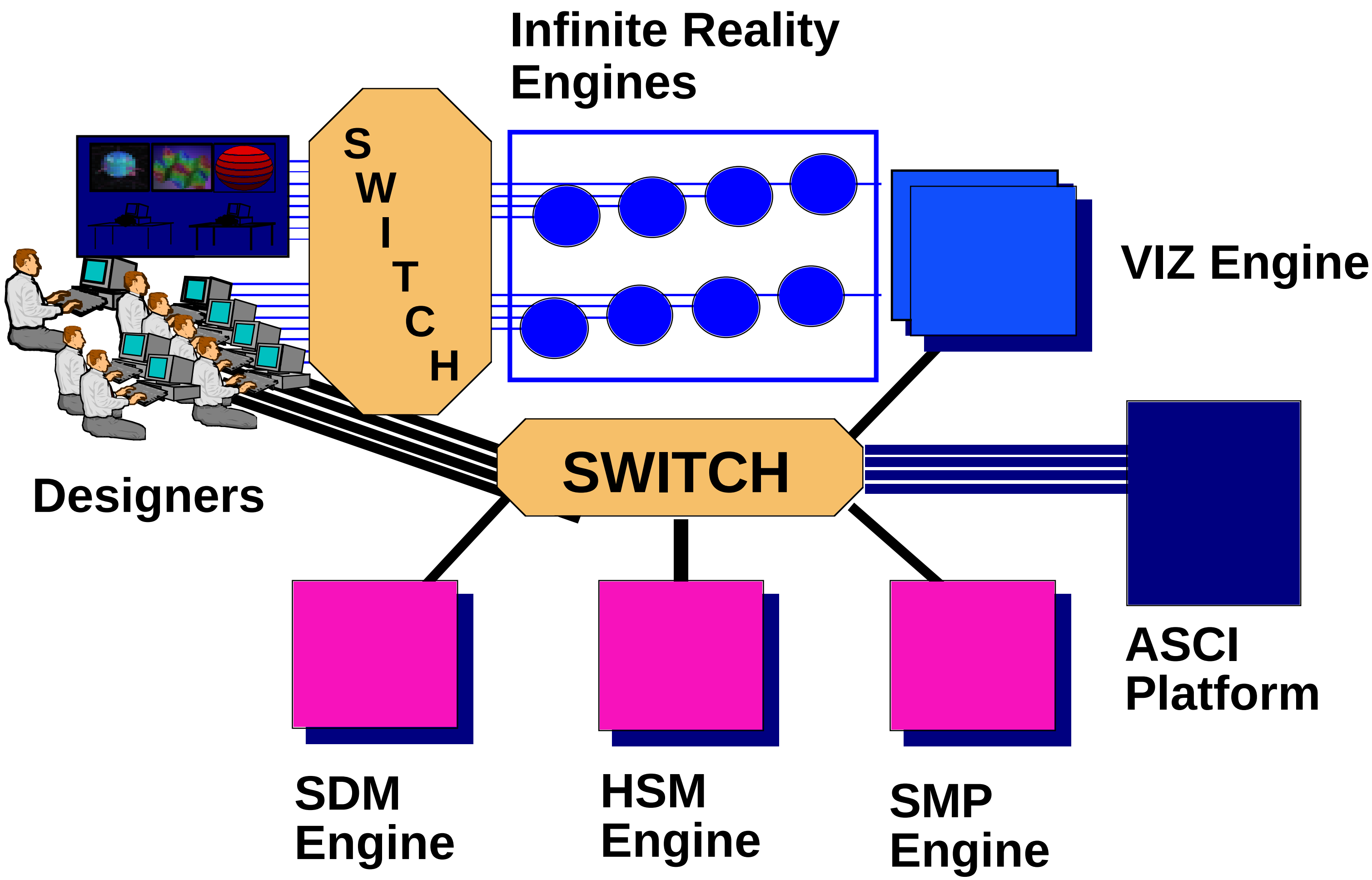
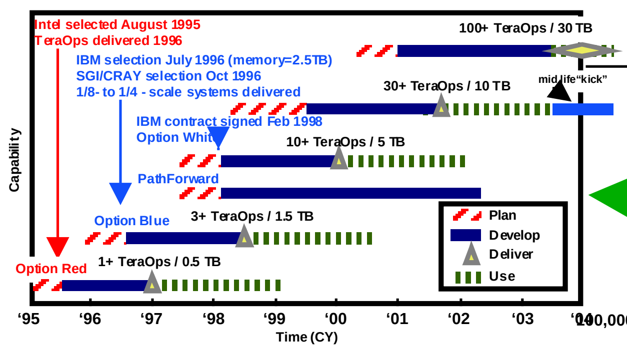
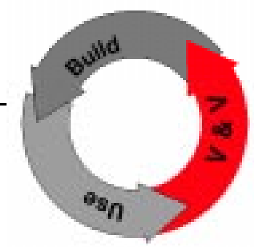


ASCI Curves Derived from Applications

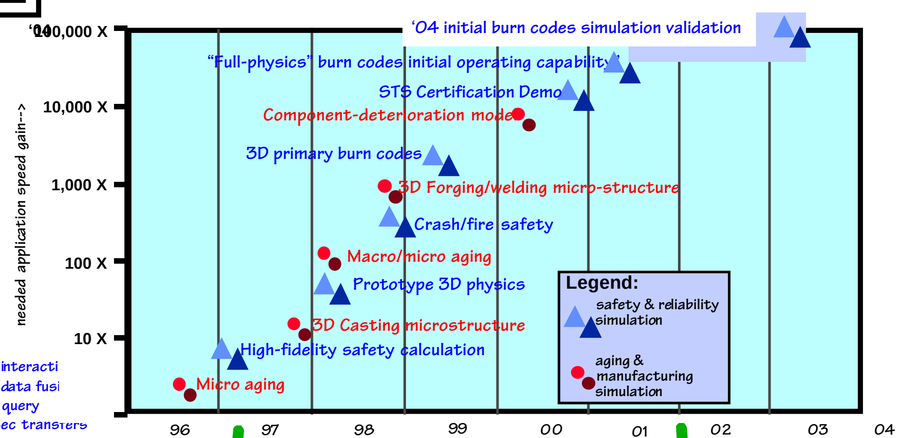


Platforms

V & V



Applications



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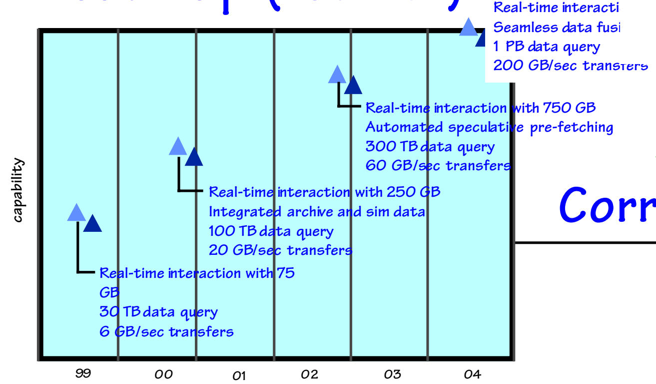
SuperCorridors Roadmap ("Curve")



Corridors

Alliances

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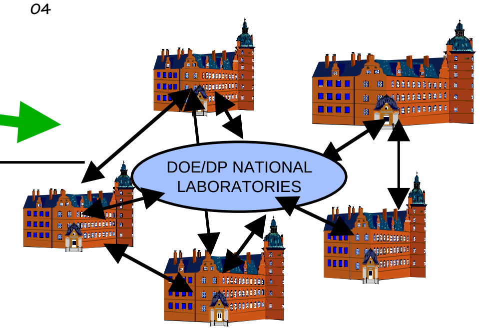
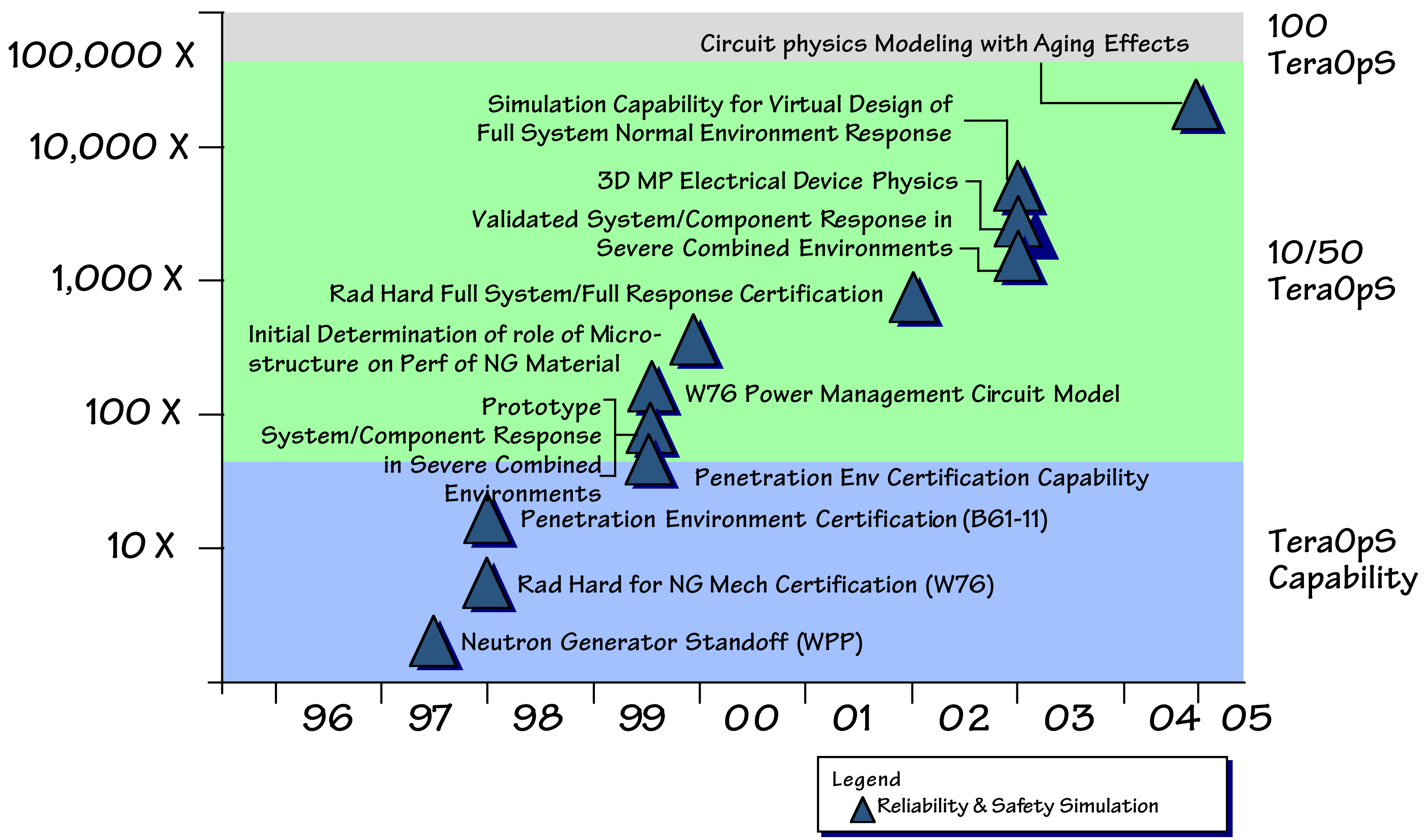


Non Nuclear Codes Roadmap ("Curve")

…3D - "more-complete-physics" - high fidelity simulation, has key milestones tied to stockpile requirements or expected aging & manufacturing requirements - i.e., Green Book or SDR



Virtual Prototyping Codes Roadmap ("Curve")

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